CLAIMS

We Claim:

1. A method for performing coupled finite analyses to resolve a joint problem using first and second finite analysis programs,

the first finite analysis program acting upon first program input values to provide first program output values based upon the first program input values, and

the second finite analysis program acting upon second program input values to provide second program output values, the second program input values including a first joint data set having at least a subset of the first program output values, the second program output values including a second joint data set of values that can be used as first program input values,

one of the first and second finite analysis programs being a computational fluid dynamics program, and

the method comprising the steps of:

(A) identifying the joint problem through use of a graphical user interface operable to identify the joint problem, wherein both the first and second finite analysis programs can jointly and in combination solve the joint problem, and to specify at least one criterion for the joint solution;

(B) providing the first program input values to the first program;

(C) executing the first finite analysis program to obtain the first program output values including the first joint data set;

(D) providing the second finite analysis program with second program input values including the first joint data set;

(E) executing the second finite analysis program to provide second program output values including the second joint data set; and

(F) providing the first finite analysis program with first program input values including the second joint data set.

2. The method according to claim 1, wherein the criterion for the joint solution specified by the graphical user interface includes an iterative convergence criterion for threshold convergence of the joint solution and the method comprises the step of

(G) repeating steps C, D, E, and F until the threshold convergence is achieved.

3. The method according to claim 2, wherein the iterating step (G) is performed automatically and without user intervention after a first time of performing steps (A) through (F).

Program Selections

4. The method according to claim 1, wherein:

the step (A) of identifying the joint problem includes selecting the joint problem as one in which one of the first and second first finite analytical programs is the

computational fluid dynamics program and the other of the first and second finite analytical program addresses a problem selected from the group consisting of structural analysis problems, heat transfer problems, chemical reaction problems, chemical equilibrium problems, internal ballistics problems, and fracture mechanics problems.

5. The method according to claim 1 including a third finite analysis program acting upon third program input values selected from the group consisting of the first program output values, the second program output values, and combinations thereof to provide third program output values,

the third program output values include a third joint data set comprising input values selected from the group consisting of first program input values, second program input values and combinations thereof, and

the method includes a step (G) of executing the third program to produce the third program output values including the third joint data set.

6. The method as set forth in claim 5 including a step (H) of providing the third joint data set to the first and second finite analysis programs, the third joint data set comprising input values selected from the group consisting of the first program input values, the second program input values and combinations thereof.

7. The method according to claim 6, wherein the criterion for the joint solution specified by the graphical user interface includes an iterative convergence criterion for threshold convergence of the joint problem and the method comprises the step of

(I) iterating with repetition of steps C, D, E, F, G and H until threshold convergence is achieved.

Manner of execution

8. The method according to claim 1, wherein the providing step (D) is performed automatically and without user intervention following the executing step (C).

9. The method according to claim 1, wherein the providing step (F) is performed automatically and without user intervention following the executing step (E).

GUI Insertion of New Programs

10. The method according to claim 1, wherein the graphical user interface includes an interface for selecting the joint problem including an additional program and for creating a user-specified data link operable to provide the additional program with shared input values selected from the group consisting of the first program output values, the second program output values, and combinations thereof, and

the method comprises selecting the joint problem including the additional program through use of the interface.

11. The method according to claim 10, wherein the additional program acts upon the shared input values and creates shared output values selected from the group consisting of first program input values, second program input values, and combinations thereof, and

the method includes providing the shared output values to the first and second finite analysis programs as specified by the user.

12. The method as set forth in claim 1, wherein the computational fluid dynamics program comprises a crack-combustion program.

13. The method as set forth in claim 12, wherein the method comprises means for modeling crack combustion in a missile based upon computed tomography taken from a missile.

14. The method as set forth in 13, wherein the other of the first and second programs comprises a structural mechanics program.

Scripting Language

15. The method according to claim 1, wherein the step of identifying the joint problem includes using the graphical user interface to select from a list of preprogrammed functions.

16. A system for obtaining a solution in the form of a threshold convergence for a joint problem, the system comprising:

a storage medium for storing first and second finite analysis programs;

a processor operably coupled to the storage medium for executing the first and second finite analysis programs;

an input device operably coupled to the processor for providing first program input values and second program input values;

the first finite analysis program acting upon the first program input values to provide first program output values based upon the first program input values;

the second finite analysis program acting upon the second program input values including a first joint data set having at least a subset of the first program output values, the second program output values including a second joint data set of values that can be used as first program input values,

one of the first and second finite analysis programs being a computational fluid dynamics program;

a graphical user interface operable to identify a joint problem that both the first and second finite analysis programs can jointly and in combination solve, and to specify at least one criterion for a joint solution;

the processor having a first operational state for executing the first finite analysis program to obtain the first program output values including the first joint data set;

the storage medium configured for providing the second finite analysis program with second program input values including the first joint data set;

the processor having a second operational state for executing the second finite analysis program to provide second program output values including the second joint data set; and

the storage medium configured for providing the first finite analysis program with first program input values including the second joint data set.

17. The system as set forth in claim 16, wherein the criterion for the joint solution specified by the graphical user interface includes an iterative convergence criterion for threshold convergence of the joint solution and the system comprises

program instructions for repeating calculations until the threshold convergence is achieved.

18. The system as set forth in claim 17, wherein the program instructions for repeating calculations operates automatically until threshold convergence is achieved.

Program Selections

19. The system as set forth in claim 16, wherein the graphical user interface comprises a menuing system for selecting the joint problem as one in which one of the first and second finite analytical programs is a computational fluid dynamics program and the other of the first and second finite analytical programs addresses a problem selected from the group consisting of structural analysis problems, heat transfer problems, chemical reaction problems, chemical equilibrium problems, internal ballistics problems, and fracture mechanics problems.

20. The system as set forth in claim 16 including a third finite analysis program acting upon third program input values selected from the group consisting of the first program output values, the second program output values, and combinations thereof, to provide third program output values,

the third program output values include a third joint data set comprising input values selected from the group consisting of the first program input values, the second program input values and combinations thereof, and

the processor is configured for executing the third program to produce the third program output values including the third joint data set.

21. The system as set forth in claim 20 including a predetermined data linkage for providing the third joint data set to the first and second finite analysis programs with corresponding input values selected from the group consisting of the first program input values, the second program input values and combinations thereof.

22. The system as set forth in claim 21, wherein the criterion for the joint solution specified by the graphical user interface includes an iterative convergence criterion for threshold convergence of the joint problem and the system comprises:

program instructions for iterating until threshold convergence is achieved.

23. The system as set forth in claim 16, wherein the graphical user interface includes an interface for selecting the joint problem as one including an additional program and for creating a user-specified data link operable to provide the user-specified additional program with shared input values selected from the group consisting of the first program output values, the second program output values, and combinations thereof.

24. The system as set forth in claim 23, wherein the additional program acts upon the shared input values and create shared output values selected from the group consisting of the first program input values, the second program input values, and combinations thereof, and

system comprises a predetermined data linkage for providing the shared output values to the first and second finite analysis programs as specified by the user.

25. The system as set forth in claim 16, wherein the computational fluid dynamics program comprises a crack combustion program.

26. The system as set forth in claim 25, wherein the system comprises means for modeling crack combustion through use of the crack combustion program in a missile based upon computed tomography taken from the missile.

27. The system as set forth in claim 26 wherein the other of the first and second programs is a structural mechanics program.

28 The system as set forth in claim 16, wherein the system comprises program instructions for identifying the joint problem by use of the graphical user interface to select from a list of preprogrammed functions.

29 ~~28~~. The system as set forth in claim 28, comprising the preprogrammed functions being in an extensible object oriented scripting language possessing looping and decisional logic capabilities.

30 ~~29~~. A computer readable form for use in an operating environment where there exists

an input device for providing first program input values and second program input values;

a storage medium for storing first and second finite analysis programs;

a processor operably coupled to the storage medium for executing the first and second finite analysis programs;

the first finite analysis program acting upon first program input values to provide first program output values based upon the first program input values;

the second finite analysis program acting upon second program input values including a first joint data set having at least a subset of the first program output values, the second program output values including a second joint data set of values that can be used as first program input values,

one of the first and second finite analysis programs being a computational fluid dynamics program;

the machine-readable form comprising machine executable instructions operable to provide:

a graphical user interface operable to identify a joint problem that both the first and second finite analysis programs can jointly and in combination solve, and to specify at least one criterion for a joint solution;

providing the first program input values to the first program;

executing the first finite analysis program to obtain the first program output values including the first joint data set;

providing the second finite analysis program with second program input values including the first joint data set;

executing the second finite analysis program to provide second program output values including the second joint data set; and

providing the first finite analysis program with first program input values including the second joint data set.

31 32. The computer readable form as set forth in claim 31, wherein the criterion for the joint solution specified by the graphical user interface includes an iterative convergence criterion for threshold convergence of the joint solution, and the computer readable form comprises instructions for repeating calculations until the threshold convergence is achieved.

32 33. The computer readable form as set forth in claim 31, wherein:

the graphical user interface comprises instructions for selecting the joint problem as one in which one of the first and second programs is the computational fluid dynamics programs and the other of the first and second programs addresses a problem selected from the group consisting of structural dynamics problems, heat transfer problems, chemical reaction problems, chemical equilibrium problems, internal ballistics problems, and fractional mechanics problems.

33 34 The computer readable form as set forth in claim 31, wherein the operating environment includes a third finite analysis program acting upon third program input values selected from the group consisting of the first program output values, the second program output values, and combinations thereof to provide third program output values,

the third program output values include a third joint data set comprising input values selected from the group consisting of the first program input values, the second program input values and combinations thereof, and

the computer readable form includes instructions for executing the third program to produce the third program output values including the third joint data set.

34 ~~36~~. The computer readable form as set forth in claim 34 including instructions for providing the third joint data set to the first and second finite analysis programs with corresponding input values selected from the group consisting of the first program input values, the second program input values and combinations thereof.

35 ~~35~~ The computer readable form as set forth in claim 35, wherein the criterion for the joint solution specified by the graphical user interface includes an iterative convergence criterion for threshold convergence of the joint problem and the computer readable form comprises:

instructions for iterating until threshold convergence is achieved.

36 ~~37~~. The computer readable form as set forth in claim 31, wherein the graphical user interface includes an interface for identifying the joint problem as one including an additional program and for creating a user-specified data link operable to provide the user-specified additional program with shared input values selected from the group consisting of the first program output values, the second program output values, and combinations thereof.

37 38. The computer readable form as set forth in claim 37, wherein the user-specified additional program acts upon the shared input values and creates shared output values selected from the group consisting of the first program input values, the second program input values, and combinations thereof, and

the computer readable form comprises instructions for providing the shared output values to the first and second finite analysis programs as specified by the user.

38 39. The computer readable form as set forth in claim 31, wherein the computational fluid dynamics program is a crack combustion program, and the computer readable form comprises instructions for modeling crack combustion in a missile based upon computed tomography taken from the missile through use of the crack combustion program.

39 40. The computer readable form as set forth in claim 31, wherein the program instructions are operable for identifying the joint problem by use of the graphical user interface to select from a list of preprogrammed functions.

40 41. The computer readable form as set forth in 40, comprising the preprogrammed functions written in an extensible object oriented scripting language possessing looping and decisional logic capabilities.

41 42. A computer readable form for use in an operating environment where there exists

an input device for providing first program input values and second program input values;

a storage medium for storing first and second finite analysis programs;

a processor operably coupled to the storage medium for executing the first and second finite analysis programs;

the first finite analysis program acting upon first program input values to provide first program output values based upon the first program input values;

the second finite analysis program acting upon second program input values including a first joint data set having at least a subset of the first program output values, the second program output values including a second joint data set of values that can be used as first program input values,

the machine-readable form comprising machine executable instructions operable to provide:

a scripting language with a preprogrammed function library operable to identify a joint problem that both the first and second finite analysis programs can jointly and in combination solve, and to specify at least one criterion for a joint solution;

providing the first program input values to the first program;

executing the first finite analysis program to obtain the first program output values including the first joint data set;

providing the second finite analysis program with second program input values including the first joint data set;

executing the second finite analysis program to provide second program output values including the second joint data set; and

providing the first finite analysis program with first program input values including the second joint data set.

42 ~~43~~. The computer readable form as set forth in claim 42, wherein the criterion for the joint solution specified by the scripting language includes an iterative convergence criterion for threshold convergence of the joint solution, and the computer readable form comprises instructions for repeating calculations until the threshold convergence is achieved.

43 ~~44~~. The computer readable form as set forth in claim 42, wherein:

the function library comprises instructions for selecting the joint problem as one in which one of the first and second programs is the computational fluid dynamics programs and the other of the first and second programs addresses a problem selected from the group consisting of structural dynamics problems, heat transfer problems, chemical reaction problems, chemical equilibrium problems, internal ballistics problems, and fractional mechanics problems.

44 ~~45~~. The computer readable form as set forth in claim 42, wherein the operating environment includes a third finite analysis program acting upon third program input values selected from the group consisting of the first program output values, the second program output values, and combinations thereof to provide third program output values,

the third program output values include a third joint data set comprising input values selected from the group consisting of the first program input values, the second program input values and combinations thereof, and

the function library includes instructions for executing the third program to produce the third program output values including the third joint data set.

45 ~~46~~. The computer readable form as set forth in claim 45, including instructions for providing the third joint data set to the first and second finite analysis programs with corresponding input values selected from the group consisting of the first program input values, the second program input values and combinations thereof.

46 ~~47~~ The computer readable form as set forth in claim 46, wherein the criterion for the joint solution specified by the scripting language includes an iterative convergence criterion for threshold convergence of the joint problem and the computer readable form comprises:

instructions for iterating until threshold convergence is achieved.